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Economic issues in the evolution of national geospatial data infrastructure

Submitted by the Secretariat**

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Economic Issues in the Evolution of National Geospatial Data Infrastructure.[1]

Richard Groot[2]

1.- Background.

Resolution 6 of the 15 th UN Regional Cartographic Conference for Asia and the Pacific held in Kuala Lumpur in April 2000 was passed to recognise that economic issues concerning modern National Surveying and Mapping, National Geospatial Data Infrastructure (NGDI), and Land Administration need to be given attention on the agendas of future UN Regional Cartographic Conferences. (Appendix 1). The main objective of the suggested Workshop on this subject, to be hosted by the Government of India, Ministry of Science and Technology, will be to attempt to map out the scope and priorities of the elements of this subject. This in turn will help to set specific agenda items and invite relevant papers in the UN Regional Cartographic Conferences.

In line with this, and taking advantage of the presence of two economists, the U. N. Economic Commission for Africa: - Ad- Hoc Group of Experts Meeting on "Study on the future orientation of the Geoinformation activities in Africa held from 6- 10 November 2000 in Addis Ababa, Ethiopia, included a meeting of a Working Group on Economic Aspects of Geoinformation[3]. In the half day available to the Working Group it attempted to take a first crack at mapping out the scope of the economics of geoinformation activities. Its draft report is attached as Appendix 2.

The present paper takes off from the results of the UNECA Working Group and tries to consolidate some of its questions with respect to the possible quantification of some of the convictions we hold so closely as self evident in the community of National Mapping Agencies (NMAs). These convictions are usually presented qualitatively and for those in our bureaucracies who do not share this self evidence, some economic quantitative calibration may be very useful, to get a sense of perspective on the importance of the work done by

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[1] Background paper for the 7 th United Nations Regional Cartographic Conference for the Americas, 22- 26 January, 2001, New York, USA.

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[3] I wish to recognize the contribution of all members of the Working Group to the stimulating discussion and to the encouraging results: Jacob Gyamfi- Aidoo, Liz Gavin, Pal Foyn Jespersen, and Helge Donnum

(NMAs). This in turn is likely to be useful in maintaining or increasing resources in support of essential national geoinformation activities. Hence illuminating the economic quantification of the assumptions made in supporting claims for budgets and regulatory initiatives must be seen as an important part of capacity building in NMAs.

The questions are presented as possible items for the agenda's of UNRCCs. Furthermore, as an example of an important aspect of the economics of geoinformation activities the results of an investigation into the requirements for efficiency in pricing and distribution of government's foundation data, under the constraints of certain normative government policy goals, together with the consequences for the corporate governance of National Survey Agencies will be presented as a case.

As it is impossible to deal with all aspects of national geomatics in the first part of this exercise, as suggested in the Kuala Lumpur Resolution 6, I have limited the content of this background paper to the production and dissemination of Foundation Data in the context of National Geospatial Data Infrastrucuture (NGDI).

2.- Introduction

Since the late 1980s a substantial literature has been built up of elements of the subject (National) Geospatial Data Infrastructure.((N)GDI). In the earlier part of this period the emphasize was not solely on the "national" aspect but on what the GDI concept is to achieve, namely the sharing of data and information once it had been collected. See for example Anderson (1990). This sharing could be imposed for example as a deliberate requirement of accountability by a manager for reasons of efficiency of information use within an enterprise, a municipality, a major project or routine activity crossing administrative, political or international boundaries etc.

The "national" focus gained prominence following the publication of the Executive Order concerning the coordination of geographic data acquisition and access in the United States Federal Government, Clinton (1994). It elevated the issue of National Spatial Data Infrastructure[4] from a technical subject to one being essential for the social and economic development of the country. Subsequently the Mapping Sciences Committee of the U. S.

National Academy of Sciences released three studies dealing authoritatively with the further development of this vision. See Mapping Sciences Committee (1990, 1993, 1994). In the early 90s the issue had, in the same context, also attracted the attention at the national and supra-national level in Canada, Australia , see for example Grant (2000) and New Zealand, and the European Commission. Many developing countries attempt to follow the institutional approach of the United States, mainly due to its excellent effort of keeping the world up to date with US developments through the newsletter and publications of the Federal Geographic Data Committee (FGDC) and the generous availability of their national standards documentation. At the subnational level, a very well documented case is the evolution of the geospatial data infrastruture of the province of New Brunswick, see for example Finley (2000).

Even though the Executive Order placed the NGDI in an important political, social and economic context, it is remarkable that research and publications on the financing and other economic issues in the evolution of NGDI have been relatively limited.

Here are some examples. Price Waterhouse (1995) presents a cost benefit estimate of the Australian land and geographic infrastructure activities. However, the 1: 4 relationship is at least subject to further research in terms of the uncertainties of the assumptions made in the calculations. Another attempt is reflected in Coopers and Lybrandt (1996), in which at least the monopolistic character of National Surveys received attention in terms of economic theory.

In Rhind (2000) an estimate was made of the budgets of the NMAs of Great Britain and the USA, which produce the foundation data for their respective NGDI, relative to the budgets of GIS applications. Thus he obtained a "proxi" for the reduction in transaction costs in the user community generated by the national foundaton data service activity. The estimates for the USA and the UK led to the same conclusion: the budgets of national Foundation Data providers are well below one percent of those of the direct clients collectively.

Another study dealt with the theoretical requirements for efficiency in the pricing and distribution of government foundation data, Groot (2001). Significantly for the national

[4] In the sequel of this paper the term National Geospatial Data Infrastructure (NGDI) shall be used to indicate

surveys is that the analysis has also resulted in the definition of the management framework of their organisations in terms which provide a foundation for the discussion of their regulatory position. In many countries the latter is a complicated matter when confronted with their responses to privatization initiatives.

3.-What is the interest of governments in efficient geospatial data supply?

Governments need geospatial data, referenced and defined in the national context, to govern. Examples are in legislative and policy development, for the allocation and management of natural resources, for defence and public safety, in support of a variety of regulatory activities. More generally, good governance requires promoting the development and understanding of knowledge about the physical, economic and human geography of the nation. To satisfy these requirements, the data is organised in a national co-ordinate system or "geodetic datum", while the data definitions are made consistent for the whole country. There is often a temporal dimension as well recording how some feature has changed over time.

A key characteristic of these standardised government geospatial data is the possibility of multiple, often unpredictable, applications inside as well as outside government. These unintended benefits are, in economic terms, "positive externalities".

At the most senior levels of government, high expectations have been expressed about the beneficial effects of the 'information society' or 'information economy', for example, for the delivery of healthcare, transportation management, life-long learning, sustainable development[5], etc. The role of the private sector in providing the communications infrastructure and the so-called 'value-added' information services is emphasised strongly. Recognising that the government itself is a very large source as well as user of such data, efficient and easy access to these sources becomes a high priority. Hence these expressions of policy signal that facilitating access to government owned data results in increasing positive externalities and reducing transaction costs to society as whole. These expectations have been articulated in, for example, EC (1994), Clinton (1994), and in EC (1998).

In this context the notion of the sharing of existing data through Geospatial Data Infrastructures (GDI) emerges as a significant matter of efficiency, and also as a generator of

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the development of this terminology as for example reflected in: Groot and McLaughlin (2000)

[5] Addressing concurrently the economic and environmental dimensions of resource allocation and management.

positive externalities. See for example Branscomb (1982). Groot and McLaughlin (2000) define the purpose of GDI as facilitation of access to and responsible use of geospatial data at 'affordable' prices. GDI is seen in this respect as a generalised concept which can be implemented at the enterprise level, the level of broad application domains such as coastal zone management, urban management or physical planning, or in the national context. Fig. 1 shows the idea of GDI for the application domain Environment and Physical Planning.

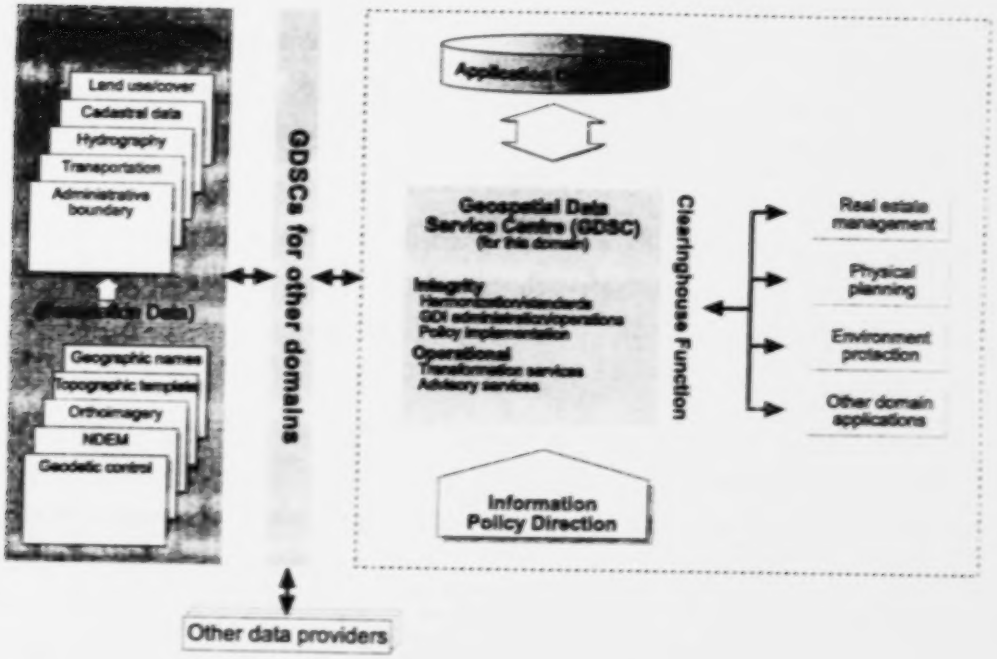

Fig. 1: The foundation data for the GDI in relation to the Geospatial Data Service Centre.

On the right hand side are the individual applications with their GIS systems, which all need routine supply of data. This stream of requirements is being met through a Geospatial Data Service Centre (GDSC). The GDSC harmonises / standardises all data for its application domain. It ensures they are described in a national meta data standard to facilitate the sharing of these resources by other potential users. The GDSC also enforces the information policies that control access, use and pricing, in keeping with legislation and overall government/ enterprise policy.

Generally speaking the National Surveys (Soil, hydrology, hydrography, vegetation, geology and geophysics etc.) are the relevant sources for the Framework Data. A special subset of these data is the Foundation Data (FD) which is the fundamental geographical reference for all other thematic application data. NMAs are usually responsible to produce, maintain and distribute the FD.

Within the context of the efficiency and effectiveness of government itself and the previously mentioned political expectations, optimal performance of NMAs and responsiveness to their client community is therefore obviously of paramount importance in reducing transaction costs in society. Since their inception (some as far as 400 years ago but most in the mid-1800's) they have enjoyed a monopoly in the technological and industrial organisation of national surveying and mapping activity.

Beginning in the mid-1970s, with the growing proliferation of Information Technology (IT), these monopolies were increasingly being challenged. The surveying and mapping technology has become increasingly embedded in software and accessible to non-specialists in the NMAs client community. Furthermore the client community obtained growing access to substitute products for the standardised topographic bases or thematic framework data sets (for example from Remote Sensing[6]). Both challenge the monopoly of the NMAs. Furthermore, the client community is increasingly changing to include for example GIS users interested in the digital data which are not the same as the digital form of the traditional topographic map content.

These effects of the ICT coincided with growing government deficits, which for most countries has led to a 20 year period of budget reductions, demands for revenue generation and, in the context of reform of government, privatisation. See for example Groot(1998). More importantly these radically changing circumstances led to critical review of the relevancy of existing and emergence of new mandates. See for example: Canadian Government (1986), Department of the Environment (1987), Mapping Sciences Committee. (1990), ANZLIC. (1996).

[6] Remote Sensing refers to Earth observation technologies from spaceborne platforms.

In spite of these studies NMAs all over the world have been slow in responding to these changes and many are experiencing major problems pushing through the restructuring necessary to move from automation to informatisation[7].

Poor performance in terms of the content, quality, efficiency and timeliness of their products leads to the NMA's client community, especially the GIS community, falling back on cheaper and often simpler but more up to date substitute products from whatever sources may be available. This in turn leads to the loss of the positive externalities outlined above, to costly duplication, reduced and incompatible accessibility of existing (government owned) data, increased transaction costs and possibly reduced timeliness in decision making processes. In many ways it impedes full exploitation of ICT for the benefit of society in geospatial data applications.

It is significant that in those countries where NMAs have successfully adapted to the dynamics of the ICT environment and the imperatives of government reform, the informatisation has been accompanied, and even led, by institutional and regulatory reform. The organisation was thereby placed in a regulatory environment in which both management and staff are motivated to be innovative and efficient and are rewarded for this. See for example Land Information New Zealand (1999).

4.- Some selected economic issues.

When considering the mission and mandates of a modern NMA, what would a thoughtful policy analyst ask to adsvise Ministers about the government's interest in the activity, what a reasonable funding level should be and to what extent innovation should be supported to improve effectiveness and efficiency of the organisation meeting the goals set for it by top level in government. She would probably address the problem by:

Two main points:

(a) Political and economic justification for investment by government in the collection and management of fundamental geo-information as a component of National Information and Communication Infrastructure (NICI)

[7] Automation: the introduction of IT to improve efficiency of existing production processes. Informatisation: the introduction of Information and Communication Technology (ICT) to respond to and develop new markets and client-oriented processes.

(b) Cost-efficient development, production and dissemination of geo-information

For the purpose of this paper and in the first instance our discussion here will be on the requirements for the foundation data production even though it is recognised that many NMAs have broader responsibilities than just that. There are of course interpretations of what the foundation data are in terms of content and scope. See for example Smith and Rhind (1999). However, for our purposes Fig 2b reflects what we shall assume to be foundation data.

4-1. The broader economic perspective.

First it should be accepted by Government that NMAs cannot be held accountable for the justification of their programs nor for their performance without some general policy guidance from the top level of Government. Government policy is in almost al cases politically inspired and thus normative, and economics cannot make a contribution in that. Once Government has declared its policy as for example in chapter 45 of this paper, economics may be a useful analytical tool to say something about the two points of interest to our policy analist.

In the broader economic perspective the markets for foundation data which describe the demand and supply functions take an important yet relatively unexplored subject. What are the characteristics of these markets? To what extent do they depart from the concept of perfectly competitive markets, for example due to the monopolistic position of the producing agency? What can be done to let the markets function as closely a possible to an open freely competitive market?

There may be distortions in the markets which may have other reasons but which nevertheless decrease efficiencies and thus increase costs. For example under the influence of donor driven programs an unrealistic demand may be met which will remain only as long as the subsidy by the donor remains in tact. When it stops the demand also dries up. This sometimes causes non-sustainability of the donor driven program.

4-2 The demand and the supply sides.

An important component influencing the demand is access to substitution. If the NMA does not deliver the required product to the quality and timeliness at a price the client considers

fair and is prepared to pay, the client will look for alternate ways to satisfy the requirement through substitution. In light of the growing penetration of affordable geospatal data production capabilities this is an option of increasing attraction especially to GIS clients. However, this may not be the case in the same measure in all countries.

In the past NMAs produced complex standard products that had to satisfy many different clients with one product. Increasingly they are now being asked to supply a diversity of geospatial data products and services on a custom made basis. If the foundation data are defined as geospatial objects and made available through object catalogues which basically are scale independent then a completely new production environment emerges which the NGA must design and implement. This will also influence the cost of the workflows, the pricing of products, the timeliness of delivery and the satisfaction of the clients. It is unfortunate that many NMAs especially in developing countries have great difficulty making this transformation. The question is if this is caused by defects in the markets or if the demand is simply not there yet and thus the basis for the necessary support for capacity building lacks. In almost all developing countries NMAs suffer for the lack of declared policy by government with respect to its expectations of the performance of its NMA in the context of declared demand in the NGDI. The performance parameters by which the agencies get measured, if at all have, no relationship to the demand in the NGDI. So how can the agency deploy? What can be done to break this deadlock?

As a result of this lack of clarity all NMAs suffer of the inability to safeguard budgets to adequate levels. They are easy targets for budget reduction exercises. To help reduce government deficits they often are instructed to introduce revenue generation. However, this conflicts with the demand of most parliamentary democracies that enlarging the budgets outside of the control of parliament is illegal. Hence their hard earned revenue goes to the general treasury and not to the organisation where the money could be used to up date plant and equipment, improve the reard systems etc. These are hardly encouraging conditions for management and staff to be innovative, efficient and client focussed. However, there are exceptions to these observations such as the Egyptian Survey Authority and the Ethiopian Mapping Agency which are, each in their own way, dealing with the newly evolving demands for their particular situations.

On the supply side price determination for products and services is a critical factor, altogether aside from important matters such as relevancy and timeliness of the product or service. Price setting depends on a fair and transparent calculation of the costs of all production input and processes. Few NMAs have, in their regulatory context of part of the Public Service, cost accounting systems in place which give answers to this. The tradition in government is to have cash flow control and line item budgets. The association of costs with products and services becomes therefore very problematic.

4.3 Results of UNECA working Group (Appendix 2)

When we consider these matters and combining this with the results of the Working Group (Appendix 2) A number of questions emerge which beg answering:

- In addressing the first point of our policy analist, we would encourage her to change the focus from collecting data and information to facilitating the development of the knowledge of the country as a whole by creating an environment in which access to and responsible use of geospatial information is facilitated at affordable costs. Howeever that implies also that there is a clientele that can in fact exploit this facility. This may mean introducing building capacity for this as early as primary school. Building knowledge and insight into the physical, social and economic geography of the country would support:
  - Good governance
  - Better allocation of resources and delivery of necessary services thereby contributing to poverty aleviation
  - Attract local and international investment
  - Expose the country's weak points but also its competitive advantage

Question: Intuitively we can get the analyst probably to get along with this. But is there any way to get a sense of the contribution of efficient and timely delivery of Foundation Data to these good things? In other words can these benefits be quantified?

Question: The claims about knowledge as reflected in point 52 of Appendix 2, can those be proven or quantified?

- On the subject of the imperfection of the markets for geoinformation or to be more specific for Foundation Data, Question: Is it possible to quantify the inefficiencies due to market imperfection?

On the subject of the positive externalities generated by the broadly available Foundation Data, Question: can externalities be quantified? Do estimates exist for availablity of Foundation Data for the market of value added products and services?

- Transaction costs

  These are the costs associated with obtaining and using a product, apart from the actual price paid, e.g.

  — cost of finding where to obtain information

  — cost of turning the data obtained into a product which is fit for intended use

Question: Is it possible to estimate reductions in transaction costs as a result of the timely availability of Foundation Data at reasonable cost?

- Cost recovery is a big issue with many governments. With respect to the Foundation Data,

(a) Question 1:

  — if a government is funding the gathering and management of foundation/framework data, should there be attempted cost recovery against demand from parties outside government?

(b) Question 2:

  — if cost recovery is not attempted, even in the longer term, what mechanisms can be used to ensure that a data producer is producing products on public money for which there is a real demand?

For possible answers see for example chapters 5 and 6 of this paper.

- As part of reducing the employment complement inside government and also hopefully in the interest of gaining efficiencies in production processes, there are many outsourcing initiatives for Foundation Data production:

Question: How far should one go with that until the asymmetry in information about production processes between government and private sector becomes so big that inefficiencies begin to occur due to increasing the overhead of control.

Thie is merely a start at identifying the questions that need to be answered to help executives of government and policy analysts to discuss in a constructive manner how the desire of governments for certain performance in the supply of Foundation Data can be justified and accomplished. One of the goals of this paper is to stimulate review of these questions and to see if other more relevant questions can be asked, with a view of attempting to get some answers.

5.- The requirements for efficiency in pricing and distribution of government geospatial data.

5-1. Key questions

While learning from the experience of regulatory reform for other natural monopolies, NMAs need to answer the following questions in developing their response to these new demands Groot(2001):

- What constitutes their Natural Monopoly in the ICT environment?
- What role can NMAs play in a competitive market for the delivery of goods and services which can no longer be considered as part of the natural monopoly? In other words, how can an NMA compete fairly in the market for these products and services?
- What institutional/regulatory environment can be created in which the motivation and rewards exist for management and staff to be responsive in a dynamic technological and developing client environment and in furthering society's interests in the broadest possible use of government owned geospatial data?

- 5-2 What constitutes the present Natural Monopoly of NMAs?

The geospatial data business can be divided into the preparation of the foundation data sets for all other public and private thematic applications as a common spatial reference for end-

users and for value –adding users. End-users take the foundation data and add atttribute values or other thematic data for their own purposes. Value adding users do the same for re-sale to third parties. In a networked digital geospatial data environment, the consistent availability of up to date and reliable foundation data opens opportunities for a broad sharing of this foundation data set with significant positive externalities to society. In addition, it facilitates participation in the information market place by all thematic geospatial data owners who apply the FD and who thus become part of the information economy. This environment is called Geospatial Data Infrastructure (GDI).

NMAs have been responsible for the production of the foundation data in hard copy form for up to 200 years and sometimes more in some countries. Before the introduction of ICT, the production processes were analogue and the output was in hard copy, highly standardised topographic maps serving a multiplicity of users with one product as shown diagrammatically in Fig. 2a. This was the old natural monopoly.

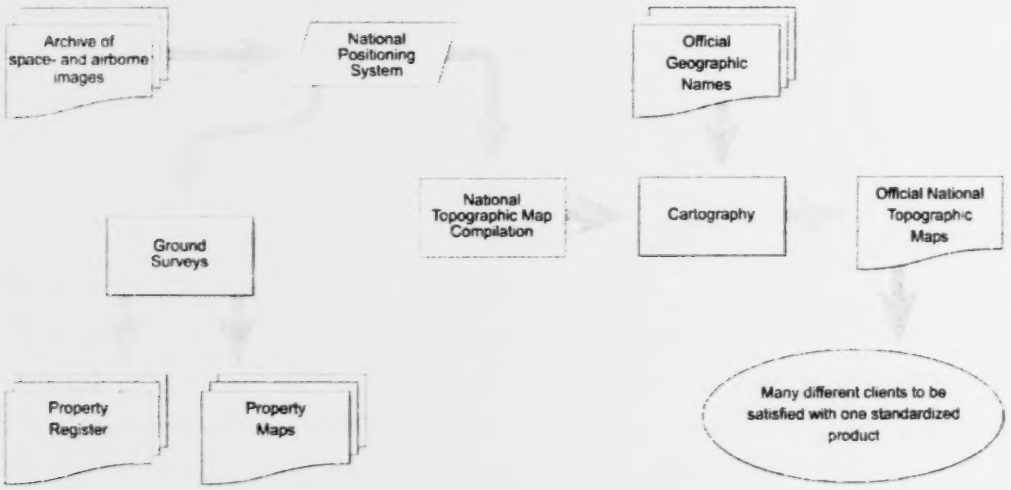

Fig. 2a: The conventional natural monopoly of NMAs .

Ubiquitous availability of digital technology has changed the business environment significantly as indicated in Fig. 2b. The source of the foundation data is also satellite and airborne imagery which, combined with the national positioning system, produces the national elevation model. To the elevation model can be added the basics of the topography to produce a so-called Topographic Template, Smith and Rhind (1999), which, properly structured, serves as a geospatial reference for thematic applications. Not all foundation data can be seen from the imagery. Official geographic names or property boundaries require ground surveys or administrative methods for their collection. The foundation data can be seen as an interrelated system, which we shall call the National Foundation Data System (NFDS). In response to the new demands for product diversity the constituent parts can also be marketed separately or in combinations.

For the purpose of this paper, the market for the NFDS has been divided (Fig. 2b) into two segments. The first segment is for analogue, special purpose maps produced on demand (but using digital methods). Note however that these maps can also be delivered in an internet environment. The second segment is of growing importance, namely the market for digital data for the Geographic Information System community. In each market the foundation data being combined with thematic data for end users or for value-added processes and products in a competitive market for a host of geospatial data applications and systems.

In this concept national topographic maps become value-added products, i.e., attribute values relevant to the content and symbology of official topographic maps are added to the topographic template. Entry into the value-added market for both market segments, including, for example, the production of national topographic map series requires relatively little capital and is not necessarily any longer part of the traditional natural monopoly of the NMAs. In fact it is expected that there will be a growing market in this field, with companies competing to meet the demand for growing product diversity when access to government owned data becomes easier. In part this also reflects the political vision presented at the start of this paper.

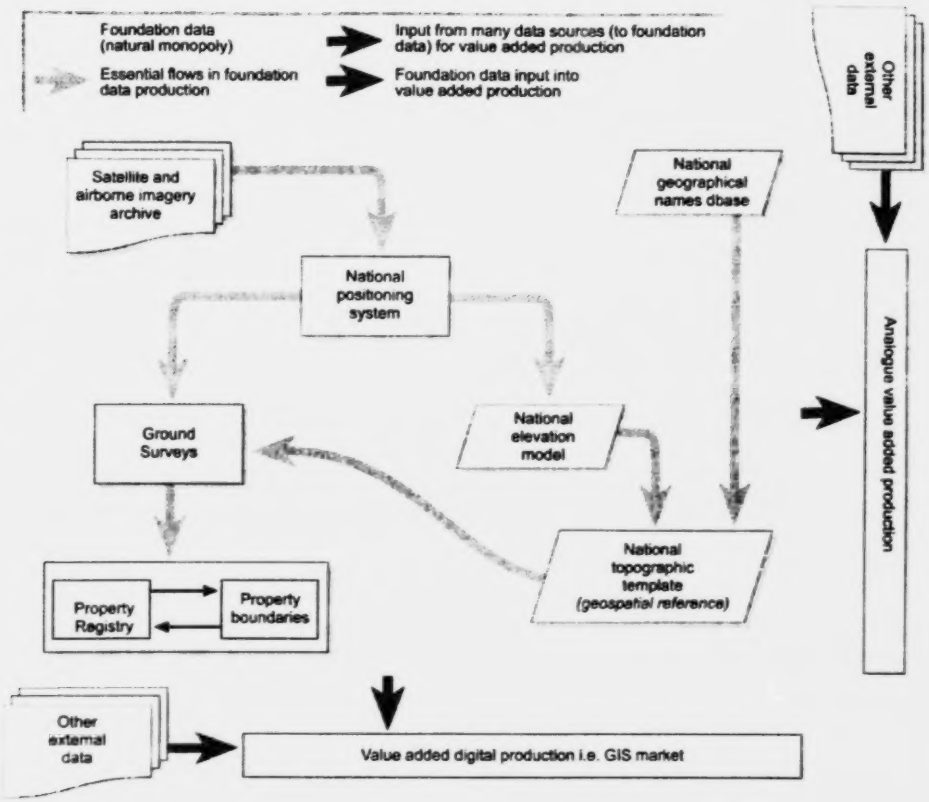
Foundation data (natural monopoly)
Input from many data sources (to foundation data) for value added production
Essential flows in foundation data production
Foundation data input into value added production
Other external data
Satellite and airborne imagery archive
National geographical names dbase
National positioning system
Analogue value added production
Ground Surveys
National elevation model
National topographic template (geospatial reference)
Property Registry
Property boundaries
Other external data
Value added digital production i.e. GIS market

Fig. 2b: The modern natural monopoly of NMAs

5-3 The National Foundation Data System (NFDS) as natural monopoly

In economics an industry is said to be a natural monopoly (NM) if a single firm can produce its vector of outputs more cheaply than any multiplicity of enterprises. The NFDS must cover the country as a whole to be of use to government. Hence, the 'relevant market' is the demand for foundation data of the country as a whole. The NFDS also has the characteristics of an imperfect public good, Coopers and Lybrand (1996) Characteristically, the sunk costs in the NFDS are many orders of magnitude larger than the cost of dissemination. Competitive entry into the NFDS business is therefore difficult and could, in fact, lead to duplication of the NFDS, which makes no economic sense whatsoever. Hence, the sunk cost *and* scale economies together deter entry into the NFDS market by other firms. Therefore of the NMAs outputs, the individual elements of the NFDS and combinations thereof qualify as a natural monopoly. Important is, however, that relatively low-cost, ubiquitous electronic surveying

Basically no monopolist is allowed to take unfair advantage of its monopoly power. This is in many countries also regulated by various forms of Anti Trust Legislation. Government information agencies are also forbidden to participate in the competitive market on the basis of cross subsidies from their government monopoly activities.

All things considered these are valuable but not complete arguments because they overlook the role of *economies of scope*. We stated earlier that the sunk cost *and* scale economies together deter entry into the NFDS market by other firms and that this leads to the NFDS being a natural monopoly. The natural monopoly position offers economies of scale in the operation especially if large scale topographic framework and property boundary data production can be combined in the NFDS, as indicated in the model shown in Fig. 2b.

If, as a result of the economies of scale of a natural monopoly, it is more efficient to produce product x and product y together in the monopolist's facilities instead of separately in different companies, society benefits from these economies, called *economies of scope*. Given the specialised know- how and capacity in an NMA due to its natural monopoly position, we should expect it to be a successful competitor, although this is by no means assured.

Mathematically this can be represented as follows:

It is in the interest of society if

$C(x;y) < C(x;0) + C(0;y)$ where $C(x;y)$ equals the cost of producing product x and product y in the same facility; while $C(x;0)$ and $C(0;y)$ are the costs of producing them in separate facilities.

$$C(x;y) - C(x;0) < C(0;y)$$

Or:

$$Ic(y) < SAC(y), \qquad (1)$$

Where Ic(y) equals the incremental cost of producing product y in addition to x in the monopolist facility and SAC(y) is the stand alone short run average cost of producing product y by itself.

Hence (1) states that the incremental cost of producing product y in the monopoly is smaller than the stand-alone cost of producing product y. These net gains to society are *economies of scope*.

Let product x be the foundation data which are necessary input for the production of value-added product y. A problem of unfair competition arises when firms compete with the NMA for the production of y for which they need the foundation data x owned by the NMA. Unless prevented from doing so the NMA will take advantage of its monopoly and charge itself less for the use of x than it charges the competition and thus compete unfairly with a lower price. If the NMA could be prevented from abuse of its monopoly, and a fair and competitive environment in the value-added (non-monopoly) part of the business could be created, the market forces, as a clear and uncontestable mechanism, will determine if (1) holds and thus if economies of scope are being realized.

This is called providing a level playing field for all competitors in the value-added business. That is, equal access to the assets of the monopolist (NMA) needed by competitors to function in the market place if the NMA is one of the competitors.

6-2 How to provide a level playing field?

Providing a level playing field is a problem of access to an asset controlled by a monopolist from which he may not derive unfair advantage, as this would distort competition. This is not an unusual issue in monopolistic situations, for example, consider competing railway companies who must use a railway bridge that is owned by one of them. In economics this is called the problem of 'bottleneck pricing'.

If the NMA were not also a supplier of value-added products in the competitive market, charging one price for the foundation data to all value-added producers that compete with one another would not constitute a competitive impediment. By avoiding differential pricing in the sale of bottleneck products or services to final product providers, they are left free to compete for customers strictly on the merits.

Society will only benefit from economies of scope if the NMA that sells the bottleneck product is also a seller of value-added products, provided equal access to all competitors including the NMA to the NFDS (the bottleneck product) can be assured.

Baumol *et al* (1997) provides the theoretical basis for dealing with this issue. This principle is called the "Parity-principle formula for bottleneck-service pricing". As applied to the NMA it would mean the following:

The minimum price P of the final(value added) product of competitor K equals the price of the bottleneck product (foundation data) P(b) *plus* the incremental cost Ic(K) of the value adding activity:

$$\text{Minimum } P(\text{final product},K) = Pb + Ic(K) \qquad (2)$$

In the case of a level playing field, the minimum price P of the final (value added) product of competitor K is equal to the price of the final value added product charged by the monopolist N *minus* the incremental cost Ic(N) of the value adding activity by the monopolist N *plus* the incremental cost Ic(K) of the value adding activity of competitor K:

$$\text{Minimum } P(\text{final product},K) = P(\text{final product}, N) - Ic(N) + Ic(K) \qquad (3)$$

(this equation defines the level playing field).

Solving (2) and (3) for Pb gives:

$$Pb = P(\text{final product } N) - Ic(N) \qquad (4)$$

where K = competitor
N = NMA (bottleneck producer, i.e. foundation data owner)
Pb = price of bottleneck product (NFDS)
Ic(K) = incremental cost of the value adding activity for the competitor K
Ic(N) = ditto for the NMA.

(4) States that a level playing field is provided if and only if the price for the foundation data charged to the competitor K is the same as the price, which the NMA charges itself. Of course the NMA, as a monopolist, will not do so out of its own volition. Therefore an independent regulator needs to oversee that this principle is being adhered to.

Sections 5.1 and 5.2 provide the conditions under which economies of scope can be realised by allowing the NMA to compete in the value added open market. For the next part of the argumentation about the requirements of economic efficiency in the pricing and distribution of National Survey materials it will be necessary to make some assumptions about government policy.

6-3 What should be a consistent price setting behaviour of the NMA on the NFDS?

We shall assume that government has three strategic goals:

i- For its own purposes and efficiency it must have guaranteed access to the NFDS at *the lowest possible cost;*

ii- In the interest of society government should also pursue the broadest possible use of the foundation data because this would multiply the *positive externalities* mentioned earlier and avoid the inefficiencies to society arising from the use of inferior substitutes which do not meet the minimum standards and specifications of reliable foundation data;

iii- In the context of reducing deficits and following the *"user pay principle"* governments will demand that the NFDS become independent of government subsidies within a reasonable time, say 5 years.

These strategic goals imply a strategic objective for the management of the NMA, namely that of maximising output subject to the constraint that economic profit cannot become negative.

In other words: to ensure the broadest possible use of the NFDS the price should be as low as possible but not so low that it requires continued government subsidy. Against this background we should have another look at pricing and market segmentation.

Figure 3 demonstrates the difference in pricing under the constraint of profit-maximising and output-maximising. The condition for profit maximising is that the long-run marginal cost (LMC) equals the marginal revenue (MR). Hence, with a given technology a monopolist

would produce the quantity Q* for which the LMC is equal to MR. For that quantity, the demand curve indicates the price P*. Profit is indicated by the shaded area Π. The output-maximising manager will set production at the point where the demand curve (D) intersects the long run average cost curve (LAC), that is at Q′ for which a price P′ is indicated. Clearly profit is zero but output is raised by the lower sales price caused by scale economies benefiting customers. Shareholders in this company would lose Π. If government is the sole shareholder, as in the case of an NMA it may be willing to forego these profits in favour of providing lower cost access to the foundation data, and achieving the positive externalities generated by broader use of the foundation data. *At the point (P′,Q′) profit is zero. Hence, if government wants to ensure full cost recovery it must stipulate prices where economic profit may not be negative.*

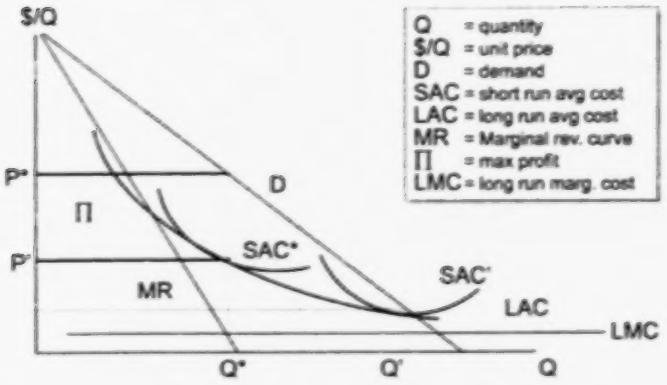

Fig. 3: Profit maximizing vis a vis output maximizing monopolists

6-4 Management discipline in defining the content of the NFDS.

Even at the price P′ the NFDS products may be so expensive that large parts of the potential client community would turn to cheaper and non standardised substitute products and thus prevent some of the positive externalities.

P′ is a function of the LAC. This, in turn, is a function of the complexity of the NFDS products such as the Topographic Template. The more complex, the higher the LAC and the higher P'. To prevent government from having to resort to subsidies to bring the price down and thus increase demand and so increase the positive externalities it should hold management to the objective of zero subsidy to be achieved over for example a five year period. This will force management to reconsider the content and complexity of the NFDS with a view of finding a balance of cost and product complexity in response to the broadest possible market.

It appears to be very difficult for NMAs to see the Topographic Template as a more simplified and specialised product than the digital copy of a topographic map. The latter is in almost all cases too complex and takes too long to produce and subsequently maintain to serve as a consistent spatial reference for most GIS users. See, for example, Department of the Environment (1987, p. 67).

Hence the economic constraint on the monopoly pricing combined with a "no subsidy in five years " policy provides management with:

- The discipline to critically review the content definition of the NFDS and guard against the addition of data which are not essential to the effectiveness of the NFDS, and
- The motivation to innovate and apply the most efficient combination of technologies and work processes to achieve the highest levels of efficiency possible.

Unfortunately, in many NMAs this discipline does not exist as the conventional topographic map content in digital form is assumed to meet the requirement of the new user community. Also the tendency exists to uncritically add new data content without real hard demand justification, thus adding to the difficulty of meeting the requirements of timeliness of production and maintenance as well as lower prices. Finally, for routine government

organisations it is very difficult to realize the motivation to be innovative and efficient due to a lack of relevant (to the market) benchmarks and due to the complexity of implementing associated reward systems for management as well as staff.

6-5 Other price setting behaviour and cross subsidies

We have suggested earlier that the market can be split into end users of individual elements of the NFDS or combinations thereof (users who apply the foundation data for their end use) and value-adding users (clients who take the foundation data and add other data to create new products, either directly for single clients or for sale in a broader market) (figure 2b).

Let us suppose that the NMA does not participate in the value-adding market. Then it would stand to reason that it charges the price P′ (fig. 3) for the elements of the NFDS. This policy would lower the prices of value-added products and services and generally have the desirable effect of stimulating the geospatial data production industry, which would be in line with contributing to meeting the high expectations of the benefits of the information society.

As we have shown above, from an economics point of view the NMA should be allowed to participate in the value-adding market if a level playing field can be guaranteed for all competitors. The condition for this is that the NMA only be allowed to charge its competitors the price for the NFDS it charges itself. For the reasons explained in the former paragraph this is the price P′.

The competitive segment of the market will determine whether economies of scope can be extracted. Although the NMA is expected to be a successful competitor, this is by no means guaranteed. In its zeal for budget reductions, government may be tempted to cross-subsidise the NFDS from the commercial activities, for example , by providing unnecessary data to the NFDS. In light of the inherent uncertainties in the competitive segment of the market this should be prevented. The NFDS must stand on its own financially, either on the basis of total cost recovery or be partly subsidised. Cross subsidy also detracts from the management discipline required to meet all 3 strategic goals mentioned in Section 5.3.

What happens to the profits from the value-added market? These should be re-invested into the enterprise to improve its efficiency. Undoubtedly some will see this as an indirect cross-subsidy to the NFDS, but we do not accept this argument. If it is in society's interest to

extract economies of scope, it follows that it is also in its interest that this is done as efficiently as possible. Reinvestment of profits from the value-added segment of the market to improve efficiency in the NFDS production environment may help realise the positive effect of economies of scope. Cross subsidy on the other hand would imply higher than necessary output or uncritically increasing data complexity.

It would be easiest to administer one price (P') for the NFDS products for all users. However, NMAs will be tempted to practise price discrimination for end-users of combinations of the NFDS elements. For institutional users, price elasticity of demand is often high. They need quality data and within bounds they will pay for it. In part this is due to the fact that relative to the financial implications of the activities for which the data are needed, the cost of the data is low. Willingness to pay can be discerned in negotiations, and in most cases a deal can be struck, for example, for issuing subscriptions to updated NFDS products, as opposed to one time sales. It would require very careful analysis of the market segments and their relative financial importance to say in how far this price discrimination would conflict with output optimisation, necessary to meet the goal of achieving the broadest possible use of the NFDS.

6-6 The role of regulation

Natural monopolies need regulation in order to ensure that they do not exploit their market power, for example by setting monopolist prices. Much has been said and written about this subject, more recently addressing the degree of overkill and the high costs of regulation. See, for example, Posner (1969) for an extensive critique of regulatory practice, or Train (1991) or Baumol and Sidak (1994) all of whom incorporate much international experience of standard regulatory mechanisms. Baumol *et al (1997)* provide a sort of bottom line for regulatory involvement as explained earlier which appears to be applicable to NMAs.

They present the principles of 'the new approach' to economic regulation. "The sole purpose of economic regulation is to facilitate and encourage effective competition where feasible, and to provide an effective substitute for competition where that is not possible, at least for a substantial period. The underlying premise of the new regulation is that where competition is effective it can do a better job of protecting and promoting the public interest than any government agency. Therefore where, and only where, competition is either absent or too

feeble to do the job, it is appropriate for the regulator to step in. But in doing so, the regulator's obligation is severely limited. It is to supply as near a substitute for the missing ingredient as can be devised, that is, to determine means to elicit the business behaviour that effective competition would have enforced if only it had been present."

In regulation of the NMA monopoly one must keep in mind the 3 strategic goals of government. It appears then that the lowest level of independent regulation must focus on:
- the level playing field.
- desirable pricing behaviour (based on output-optimisation) of the NMA;
- the ban on cross–subsidising the NFDS from the commercial value-adding activities;

As long as NMAs continue to be a standard part of the public service there are many impediments which make it next to impossible to carry out such regulation, not the least of which is the absence of complete cost-accounting systems in most government organisations. Another issue is the preferential position of government organisations with respect to the tax system.

We can now address the final question of Section 2: *What institutional environment can be created in which the motivation and rewards exist for management and staff to be efficiently responsive to the changing client environment and in furthering society's interests in the broadest possible use of government owned data?*

7- Points of departure and principles for the privatisation discussion.

In order to meet the three strategic goals of Government (Section 5.3) with economic efficiency, the following points of departure and principles will form the management framework for the NMAs:

1- For the NFDS segment of the market the NMA is a natural monopoly. Due to the government's objective of having the broadest possible use of the NFDS and thus increase positive externalities in society, the NMA operates as an output maximising monopolist,

2- The consequence of this is that the price for NFDS products must be equal to the long run average cost at a point where economic profit is not negative,

3- For society to benefit from the economies of scale and economies of scope, the NMA must be allowed to compete in the value-added market segment. This will be on condition that the parity-principle formula for bottleneck-service pricing is applied. Following this principle, the NMA would charge itself and competitors the price mentioned under 2, subject to regulatory supervision.

4- The NMA must be constituted under corporate law, with accounting and financial reporting requirements enforced. This will permit calculation of relevant costs. The legal and taxation rules must apply in just the same way as for the private sector.

5- As it is uncertain whether the NMA will compete successfully in the value-added segment of the market, society's interest demands that there be no cross-subsidy from that market to the NFDS.

6- The NMA may practise price differentiation in the end user market for combinations of elements in the NFDS.

7- Management of the NMA will be given (for example) five years to make the agency financially self-sufficient and cease being a charge on the taxpayer. To this end, it must a balance complexity of content of the NFDS and long run average cost (and, thus, price), in such a way that output is maximised. This will be the motivator for management to implement the necessary procedures with the client community to rationalise the content of the NFDS.

8- Management and staff incentive plans must be designed to promote this objective.

9- The NMA's independent regulator must be given the tools needed to:

a) oversee the implementation of the 'level playing field',

b) ensure that there are no cross-subsidies from the value-added competitive segment of the market to the NFDS,

c) ensure that pricing is in sympathy with the requirement for output maximisation, subject to the constraint of zero subsidy to be achieved in a defined and accepted time limit.

10- Profits from successful competition in the value-added segment of the market may be re-invested in the agency to improve its efficiency.

We have now stated the principles and points of departure, which define an effective business environment for the NMA in meeting the three strategic goals of Government. We have already observed that it is impossible to meet these goals under the normal regulatory

environment of Public Service. It is at this point and only at this point that discussion on privatisation or reduced ties to public service regulation has a rational context of principles.

8- Regulatory Reform and the future performance of NMAs.

Any form of increased independence from public service regulations must serve the principles and points of departure presented as prerequisites of the strategic goals of government with a well functioning NMA.

Outright privatisation of National Surveys is folly. It would place the ownership of all data assets in private hands, including the exclusive right to exploit these. Governments would thus lose complete control over strategic information assets to which they need unlimited access to govern.

It is also highly questionable whether any private enterprise would entertain a serious bid for an NMA if the requirement is that it act as an output maximising rather than a profit maximising monopolist and have no exclusive right to exploitation of the monopoly.

Furthermore, there are many uncertainties caused by the lack of commercially relevant and reliable management information about most NMAs to assess viability in the new regulatory setting. Potentially interested companies would hesitate to bid on a franchise, license, or concession, and would expect governments to pay a large risk premium.

The critical questions are really :
-What does government want to achieve with the NMA?
-What is the best regulatory environment for this?
-What price is it prepared to pay?

There are choices for solutions such as issuing a management contract, tendering for concessions or franchises, or establishment a special agency status whereby political accountability for the performance remains with a Minister of Cabinet. In different institutional environments and countries the answers may be different in finding an adequate

solution for reinventing the regulatory environment for he NMA. But in all cases the three basic questions cited here must be adequately answered.

In a number of countries some form of special agency has been developed successfully. For example, the Netherlands' Cadastre, Service New Brunswick (SNB), the Ordnance Survey of Great Britain (OS), the Danish National Survey, the NMA of New Zealand, and there may be others. Service New Brunswick and the OS were given about five years to put their houses in order and become self-sufficient or almost so. Similar targets were given to the others. In all those cases political accountability for the performance of the NMA has always remained with a Minister of Cabinet. Those organisations that have large scale and property data in their NFDS seem to have a greater chance of achieving 'independence' and self-sufficiency than those that do not.

The extent to which these agencies have followed the rather rigorous model proposed is not known. For example, little to nothing is known about (the logic of) their price setting mechanisms and their accounting systems. It will certainly be worthwhile to test the model against these real world examples and report the findings publicly.

In the author's view any solution that meets the proposed principles and points of departure will meet the requirements of efficiency in the pricing and distribution of National Survey materials. It will furthermore create the positive and motivating management environment NMAs need to fulfil their modern mandates.

9- Epilogue

The analysis of the economic efficiency of pricing and dissemination of national survey products and services was constrained by the three strategic goals or policies of the national government. In most industrial countries these are reasonably well-accepted government policies. But what if government decides to continue subsidization of the NFDS and give away the data to government departments and the public for nothing or next to nothing? Or if it decides to do so for government departments but in addition severely restrict the free dissemination of the NFDS to the public? Or if it decides to give the NMA an uncontrolled monopoly to operate in the value added market? In each instance a economic price will have to be paid. Particularly the creation of the management discipline that motivates management

of the NMA to be efficient and responsive tot the market may suffer. Governments need to decide if they want to pay that price. Also in the setting of prices governments may decide not to be as consistent as has been suggested. For a discussion on pricing issues see for example Rhind (2000). Furthermore the backdrop of the stage on which the performance of NMAs is played out is continuously changing.

Technology gallops forward and novel private sector capabilities will emerge that can provide a fully integrated geospatial data service at high accuracy, which is expected to even satisfy some municipal level applications. When such services do become available and are proven reliable, consistent and affordable, the pressure will mount on government to justify its continuing involvement in national surveying production.

For example, there are currently three US consortia being created, each owning their own satellite with high resolution (1 m), remote sensing capacity, who claim to be able to provide data but also vertically integrated value-added services. The pricing structure for these services is still not known, but having three in the market would suggest some competition. We need sound principles upon which to judge the impacts of these developments on the extent of government services. In the absence of these principles the reaction will be one of improvisation, which could be to the detriment of the country and the public.

It is in the interests of government and of society as a whole that the future can best be dealt with from a position of strength of the NMA. The alternative is a position of incompetence and inefficiency, in which solutions are being enforced by powerful external forces which give no assurance of control over the performance of information that is of strategic importance to governments.

Another aspect of emerging technological opportunity lies in the linkages between the NMA and the provincial and municipal agencies which are responsible for the local Foundation Data Systems. These new technologies will offer opportunities for increasing efficiencies by automatically or semi-automatically deriving lower resolution data at the national level from higher resolution data which have been prepared at local levels. The development of these approaches will require co-ordination between those organisations which may be better motivated if they were to be more independent of government than they are now.

It would be imperative for NMAs to respond to these challenges out of a position of strength and with thorough scientific and engineering know-how while operating in a business like environment. Only then will new developments be perceived as new opportunities to meet the requirements of their mandates instead of as threats. All the more reason to proceed with innovative approaches to provide these organisations with the regulatory environment in which innovation and efficiency in serving new and as yet unpredictable markets can flourish under fair competition with the private sector.

There is no suggestion that the role of government needs to be exactly the same in every country. The government involvement in spatial data infrastructure development and the regulatory position of the associated government agencies depend on the culture in each country or jurisdiction. There are issues of copyright protection of government owned data in most countries which do not exist in the US. Similarly the protection of the privacy of individuals and companies is not dealt with in the same way in different countries. See, for example, Buchwald (1995). Yet, in spite of these differences, it seems logical that models such as the one we have proposed would assist the decision-making process in a practical way, leading in each case to appropriate local solutions.

Even though much emphasize has been placed on the need for approaching the future of NMAs out of a position of strength, the paramount question is always: How can a government's requirement for access to geospatial data of the country be met in the most reliable, effective and efficient way? This is a different approach than arguing from what NMAs are capable of or are being allowed to do, which is the more dominant way in bureaucracies. The proposed principles and points of departure are intended to at least provide a rational starting point for the discussion between policy makers and executives about the continuing relevance of National Mapping Agencies.

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Appendix 1

Resolution 6 of the 15 th UN Regional Cartographic Conference for Asia and the Pacific, Kuala Lumpur, 11- 14 April 2000.

Economic aspects of modern surveying, mapping, geospatial data infrastructure and land administration programmes

The Conference,

Noting that all modern surveying and mapping, geospatial data infrastructure and land administration projects must compete for scarce economic resources with other valuable projects,

Recognizing that many Governments seek to reduce the cost to the taxpayer for fundamental and infrastructural geospatial data services by various forms of privatization, cost recovery, outsourcing or revenue generating initiatives,

Considering that these initiatives have a significant technical, organizational and institutional impact on national surveying and mapping,

Bearing in mind that the expanding array of options for professionals in the mapping field imposes choiees in which economics plays a decisive rote both in government and in the private sector,

1 . *Recommends* that the United Nations Secretariat within available resources, and in cooperation with ether appropriate organizations and educational institutions, initiate an international workshop en economic aspects of modern surveying, mapping geospatial data infrastructure and land administration;

2. *Welcomes* the invitation of the Government of India to host the proposed workshop.

APPENDIX 2

D. DRAFT REPORT

UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA- AD-HOC GROUP OF EXPERTS MEETING, 6- 10 NOVEMBER 2000, ADDIS ABABA, ETHIOPIA:

WORKING GROUP 4: ECONOMIC ASPECTS OF GEO-INFORMATION

47. Participants:

- Jacob Gyamfi-Aidoo (chair)
- Liz Gavin (rapporteur)
- Dick Groot
- Pal Foyn Jespersen
- Helge Donnum

48. Two main points:

(c) Political and economic justification for investment by government in the collection and management of fundamental geo-information as component of National Information and Communication Infrastructure (NICI)

(d) Cost-efficient development, production and dissemination of geo-information

51. A shift in perspective:

(a) *from* focussing on the need for mapping and generation of spatial data,

to the use of information describing the country's assets and potential in terms of its geography,

in order to gain the attention of policy makers and potential local and foreign investors

(b) Knowledge of the geography of one's country is a necessary but not sufficient condition for good governance

(c) However, it is essential to government in order to allocate resources and provide services effectively and efficiently

(d) It is needed to attract investment e.g. mining companies will not make investments unless there is documented and accessible knowledge of the geology of the country available

(e) Wider dissemination of knowledge about one's country constitutes better marketing

52. More on knowledge:

(a) Unlike other assets, knowledge appreciates in value through use and depreciates in value through lack of use

(b) Knowledge cannot be lost through sharing

(c) New knowledge may be derived through integration of different set of geographic information from different sources

Question: Have any studies been made to estimate these benefits. What about the work of Kenneth Arrow on the contribution of knowledge to the economy?

53. The marketplace for geoinformation

(a) In a perfect market, supply and demand determine pricing

(b) Imperfections in the market lead to higher prices and hence not as wide a distribution of information and knowledge

(c) Identify supply (I.e. data producers) and demand (I.e. data users)

Question: Is it possible to quantify the inefficiencies due to market imperfection?

54. Suppliers ("data producers")

(a) Government: at national, provincial, local levels

(b) Private Sector – data, technology, knowledge transfer

(c) Donors, foreign government and business

(d) Suppliers of (high resolution) remotely sensed imagery

(e) NGOs

55. Suppliers ("data producers")

(a) Government (internal) at national, provincial and local levels

(b) External governments; donors

(c) Parastatals, utilities

(d) NGOs, CBOs

(e) Private companies

(f) national,

(g) foreign

(h) Private citizens

56. Role of government (1)

Foundation/framework data needed for building national infrastructure as part of NICI, to facilitate access, responsible use and integration at affordable costs: traditionally government co-ordinates and funds the development of national infrastructure

57. Role of government (2)

(a) The creation of "positive externalities" and the reduction of "transaction costs" (see 60, 61)?

(b) Transparency of access rules, pricing and conditions of use.

(c) Knowledge of competitive advantage needed for growth

(d) provide the motor for developing further information products and services.

Question: can externalities be quantified? Do estimates exist for the market of value added products and services?

58. Benefiting from donor participation

A possible problem:

— the effect of uncoordinated donor interventions may be to create an artificial demand or undermine economies of scale by duplicating supply

59. Recommendations concerning donor contribution

(a) The co-ordination of donor interventions is needed

(b) Donors should be encouraged to contribute to building foundation/framework data within the framework of national policy concerning the systematic building of information infrastructure (NICI plans)

(c) Data products emerging from donor-funded projects should be incorporated into the national information infrastructure

60. Transaction costs

These are the costs associated with obtaining and using a product, apart from the actual price paid, e.g.

— cost of finding where to obtain information

— cost of turning the data obtained into a product which is fit for intended use

61. Reducing transaction costs

(a) Making information more easily accessible, I.e. establishing a clearinghouse

(b) Reducing effort needed to ensure that the product is fit for use:

— setting standards for geographic information

— provision of metadata describing data quality, lineage etc.

(c) Providing complete information to potential investors

Question: Is it possible to estimate reduction in transaction costs?

62. Cost recovery ?

(c) Question 1:

— if a government is funding the gathering and management of foundation/framework data, should there be attempted cost recovery against demand from parties outside government?

(d) Question 2:

— if cost recovery is not attempted, even in the longer term, what mechanisms can be used to ensure that a data producer is producing products on public money for which there is a real demand?

63. Factors to consider with respect to embarking on cost recovery

(a) Higher costs leads to lower demand, i.e. the audience receiving knowledge which could drive further investment or the creation of information products and services is narrowed

(b) There are administrative costs associated with cost recovery

(c) There is little point to this exercise unless revenue returns to the agency bearing the cost of generating the information, the dissemination and the administration.

64. Framework data sets

Def.: geographic data needed by more than one government agency for fulfilling its service delivery obligations

— Cost effective to have this captured once for use by several government agencies, I.e. economy of scale

65. Re-engineering of production process by data producers (e.g. NMAs)

(a) Technology makes it possible to be able to create many different products, customized to the needs of individual demanders

(b) A "just-in-time" (JIT) philosophy can be adopted: I.e. products are produced on demand; don't stockpile - there is a cost associated with this

(c) Even if production is outsourced, capacity needs to be retained within the outsourcing institution (avoiding "asymmetric knowledge") which may cause inefficiencies.

Question: Are there any studies of the cost of asymmetric knowledge in transactions in the economics literature?